

Physics 102

Electricity & Magnetism - Optics



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October 2015



Electricity and Magnetism

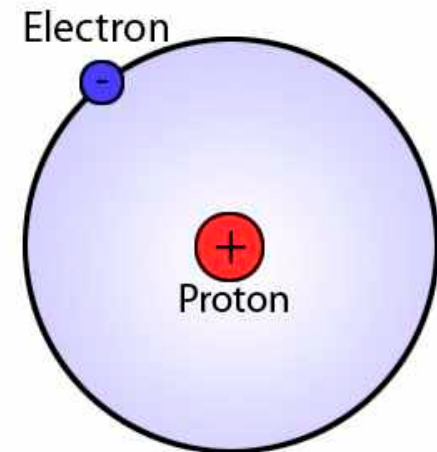
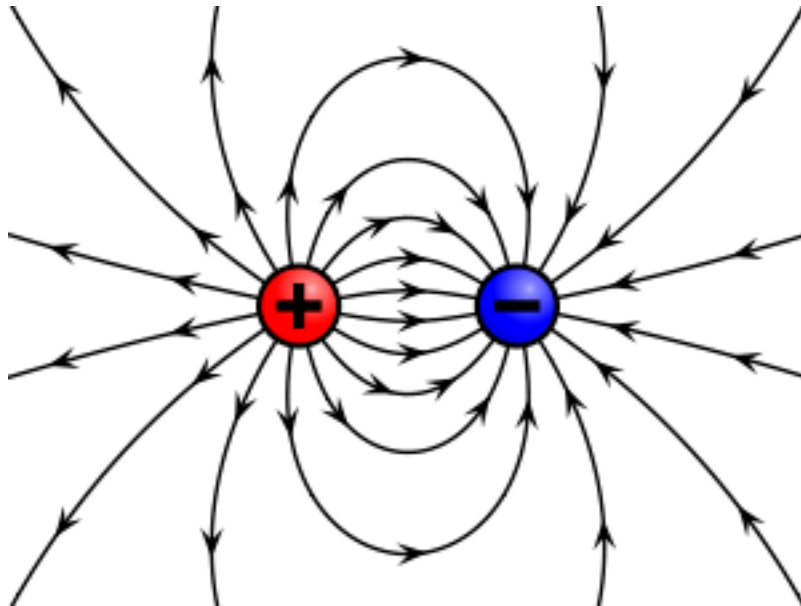
Chapter One: Electric field



- ◆ Properties of Electric Charges
- ◆ Coulomb's Law
- ◆ The Electric Field
- ◆ Electric Field of a Continuous Charge Distribution
- ◆ Electric Field Lines
- ◆ Motion of Charged Particles in a Uniform Electric Field
- ◆ Electric Dipole in an External Electric Field

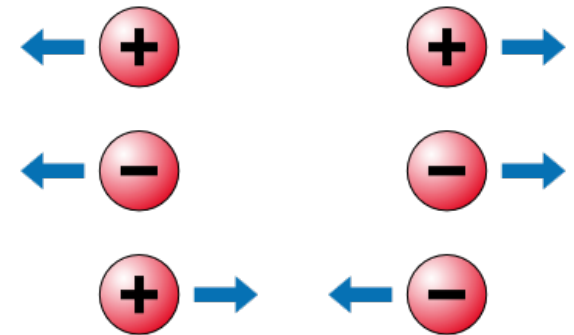
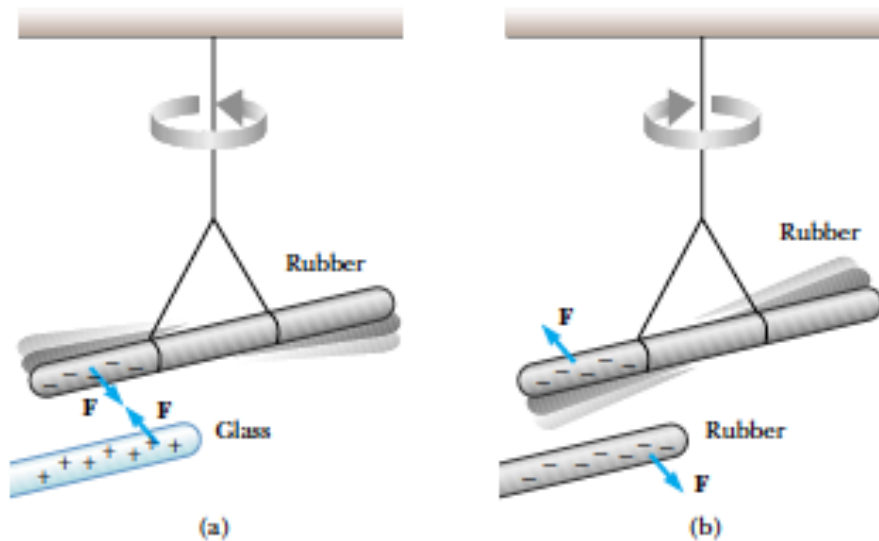
Electric Charge تَحْشِلَا تَغْيِيرَهْكَا

- There are two kind of charges in nature.



Electric Charge تَحْشِلَا تَغْيِيرَهْكَا

- The force between like (unlike) charges is repulsive (attractive).

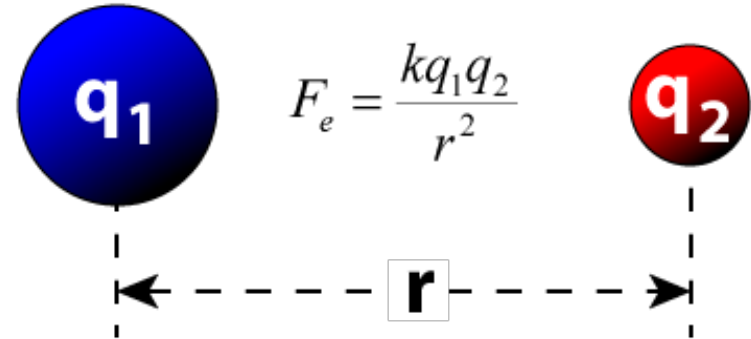


Coulomb's Law

$$F_e \propto \frac{1}{r^2}$$

$$F_e \propto q_1 q_2$$

$$F_e \propto \frac{q_1 q_2}{r^2}$$

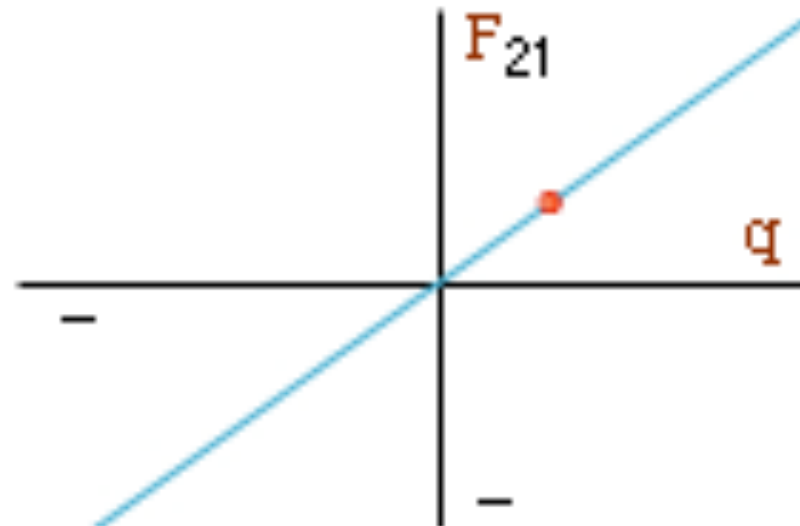
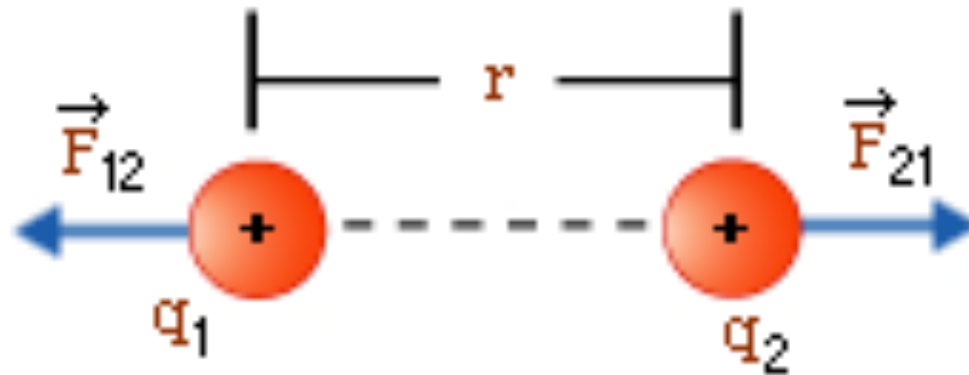


$$F_e = K \frac{|q_1||q_2|}{r^2}$$

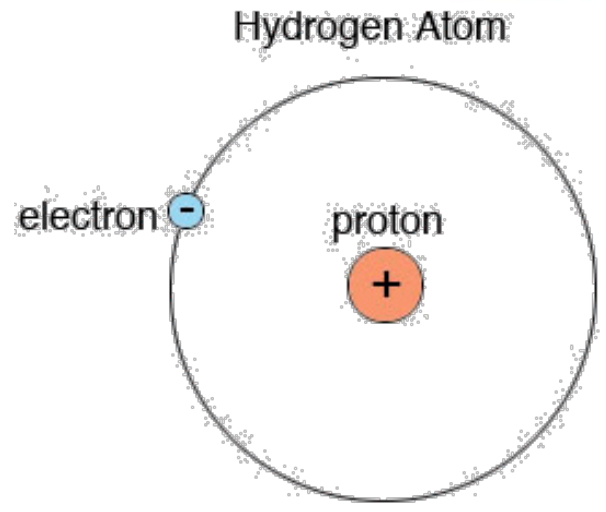
$$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2 / \text{C}^2$$

Where, K is Coulomb's constant and ϵ_0 is permittivity of free space.

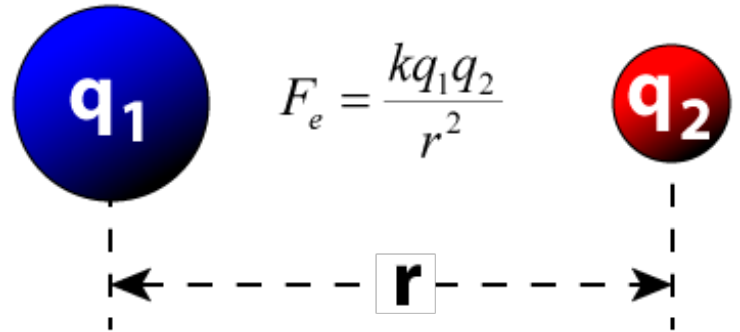
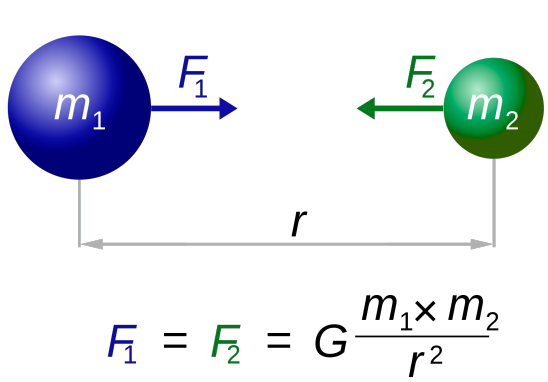
Electric Force



Hydrogen atom



Field Type	Caused By
gravity	mass
electric	charge



Example 23.1 The Hydrogen Atom

The electron and proton of a hydrogen atom are separated (on the average) by a distance of approximately 5.3×10^{-11} m. Find the magnitudes of the electric force and the gravitational force between the two particles.

Solution

$$F_e = K \frac{e^2}{r^2} = 9 \times 10^9 \frac{(1.6 \times 10^{-19})^2}{(5.3 \times 10^{-11})^2} = 8.2 \times 10^{-8} \text{ N}$$

$$F_G = G \frac{m_e m_p}{r^2} = 6 \times 10^{-11} \frac{(9.11 \times 10^{-31})(1.67 \times 10^{-27})}{(5.3 \times 10^{-11})^2} = 3.6 \times 10^{-47} \text{ N}$$

$$\therefore \frac{F_e}{F_G} = 2 \times 10^{39}$$

$$F_e / F_g \approx 2 \times 10^{39}$$

The Sub-atomic Particles			
Size	Name	Mass (Kg)	Charge (C)
	Proton	1.67×10^{-27}	$+1.602 \times 10^{-19}$
	Neutron	1.67×10^{-27}	0
	Electron	9.11×10^{-31}	-1.602×10^{-19}

The force that two point charges, Q and q , separated by a distance r , exert on one another is given by:

$$F = \frac{KQq}{r^2} \quad \text{where } K = 9 \times 10^9 \text{ Nm}^2/\text{C}^2 \text{ (constant).}$$

Quiz:

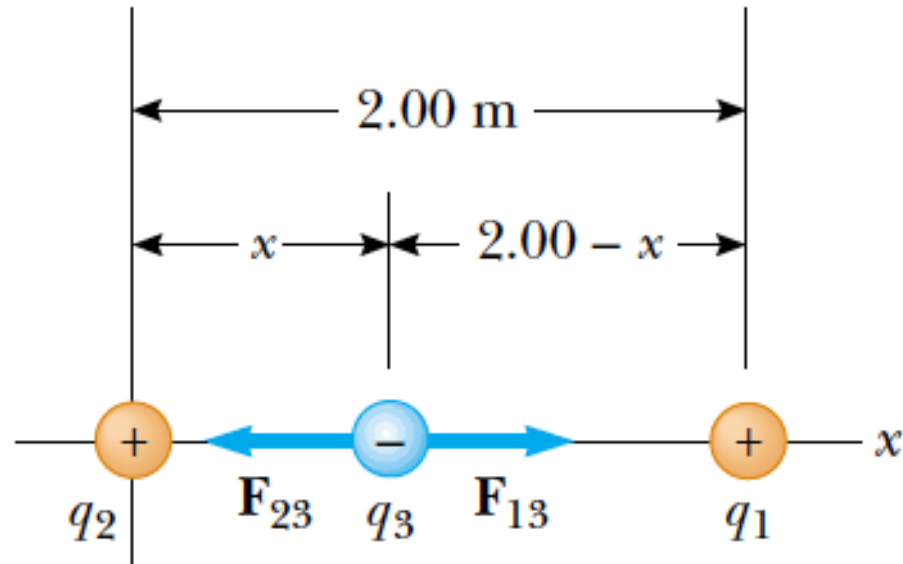
Suppose that the force two point charges are exerting on one another is F . What is the force when one charge is tripled, the other is doubled, and the distance is cut in half?

Page 6: Zero Resultant Force, Example

- Where is the resultant force equal to zero?

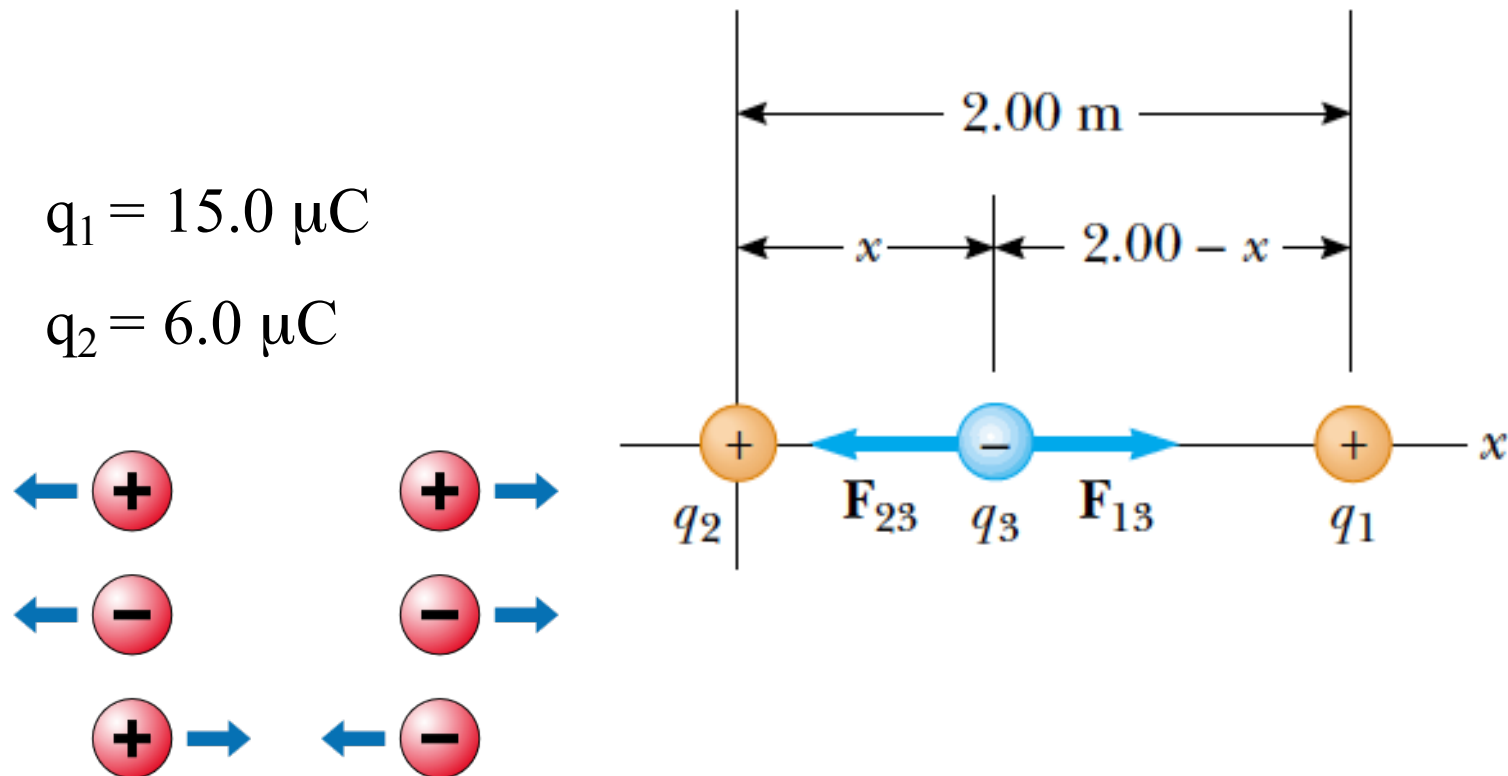
$$q_1 = 15.0 \mu\text{C}$$

$$q_2 = 6.0 \mu\text{C}$$



Page 6: Zero Resultant Force, Example

- Where is the resultant force equal to zero?



$$F_3 = 0 \Rightarrow F_{31} = F_{32}$$

$$\therefore F_{31} = K \frac{q_3 q_1}{(2-x)^2} \quad \text{and} \quad F_{32} = K \frac{q_3 q_2}{x^2}$$

$$\therefore K \frac{q_3 q_1}{(2-x)^2} = K \frac{q_3 q_2}{x^2}$$

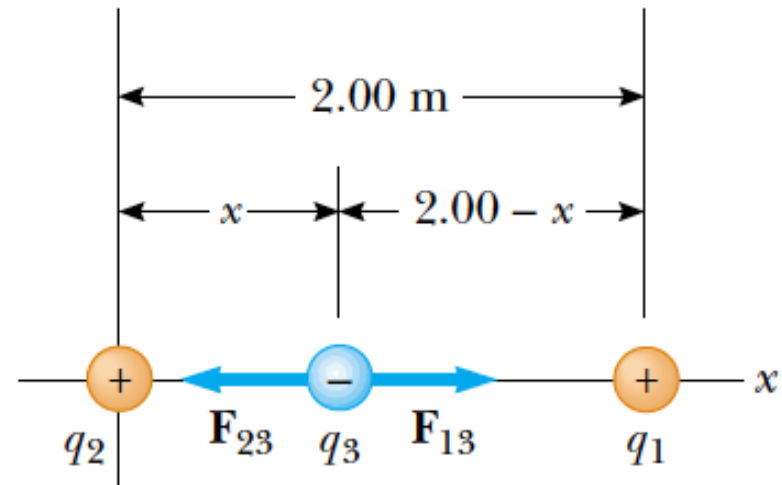
$$\frac{q_1}{(2-x)^2} = \frac{q_2}{x^2}$$

$$\frac{15 \times 10^{-6} \text{ C}}{(2-x)^2} = \frac{6 \times 10^{-6} \text{ C}}{x^2}$$

$$\frac{5}{(2-x)^2} = \frac{2}{x^2}$$

$$5x^2 = 2(4 - 4x + x^2)$$

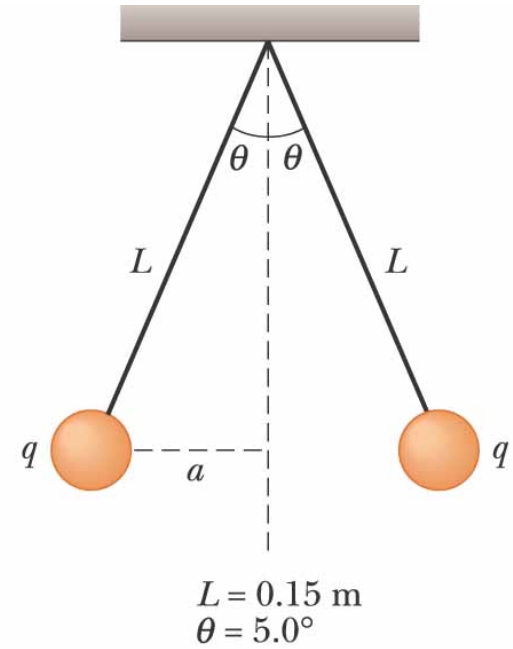
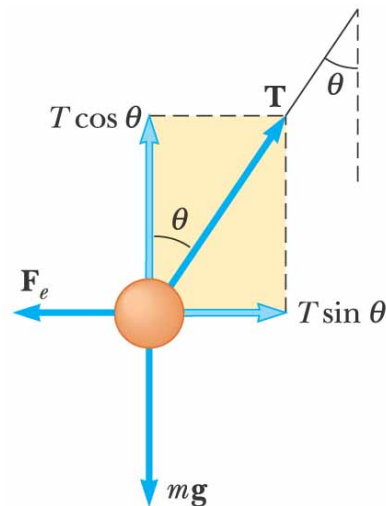
$$x = 0.775 \text{ m}$$

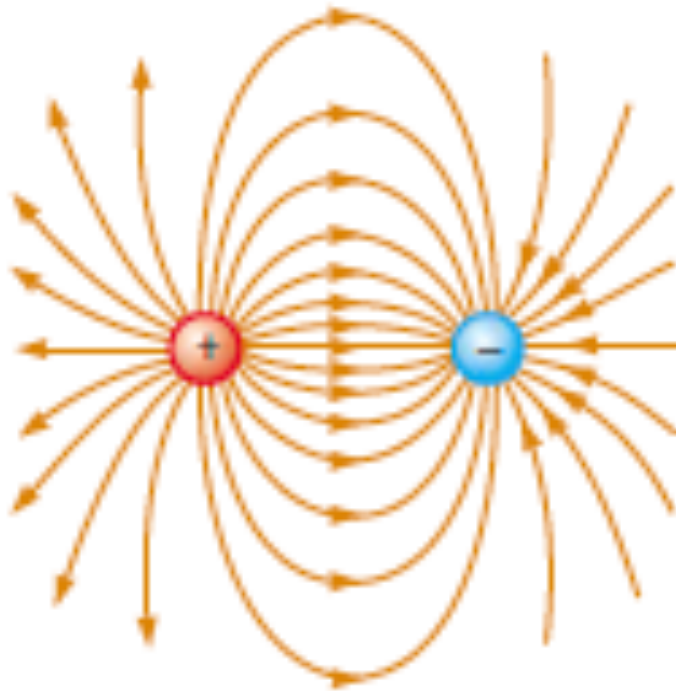


Negative value of x is rejected

Electrical Force with Other Forces, Example

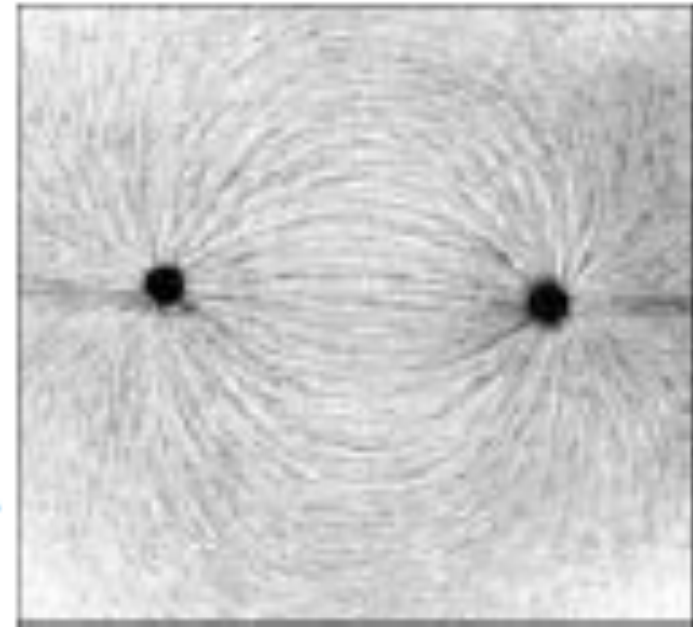
- The spheres are in equilibrium
- Since they are separated, they exert a repulsive force on each other



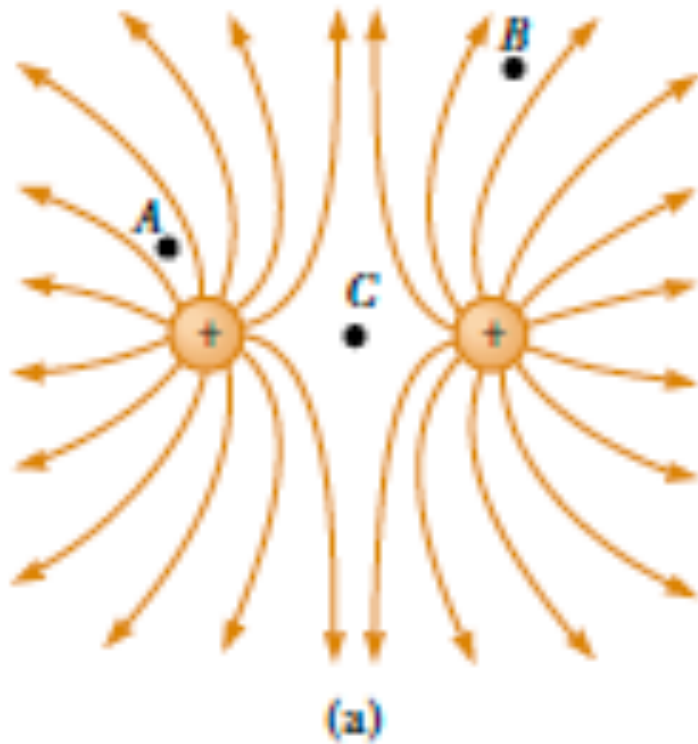


(a)

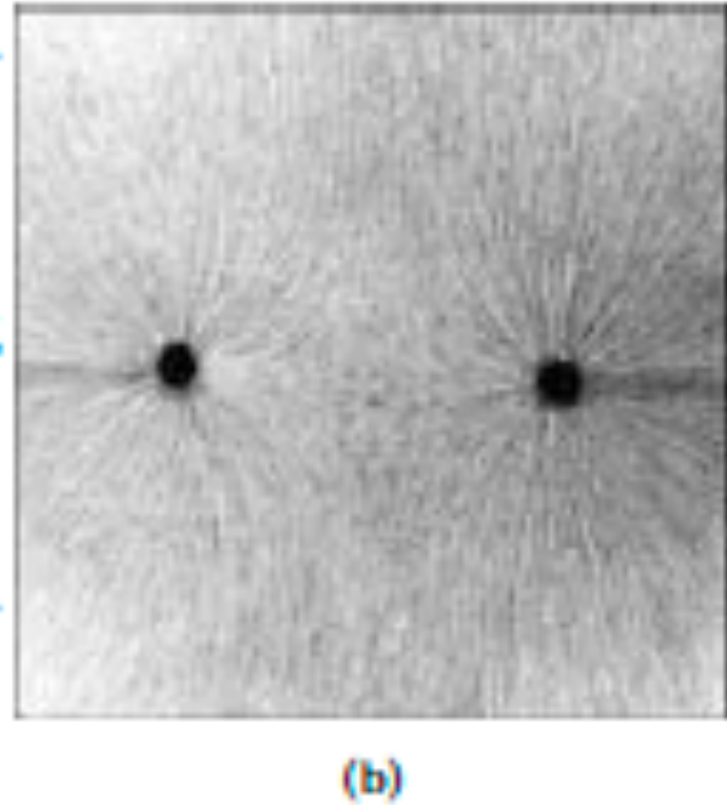
Courtesy of Miraldr M. Waupis, Polkinton University



(b)



Courtesy of Harold Mc. Mangan, Princeton University



Gauss's Law

Electric Potential

energy. The **potential difference** $\Delta V = V_B - V_A$ between two points A and B in an electric field is defined as the change in potential energy of the system when a test charge is moved between the points divided by the test charge q_0 :

$$\Delta V = \frac{\Delta U}{q_0} = - \int_A^B \mathbf{E} \cdot d\mathbf{s} \quad (25.3)$$

$$1 \text{ V} = 1 \frac{\text{J}}{\text{C}}$$

Work done

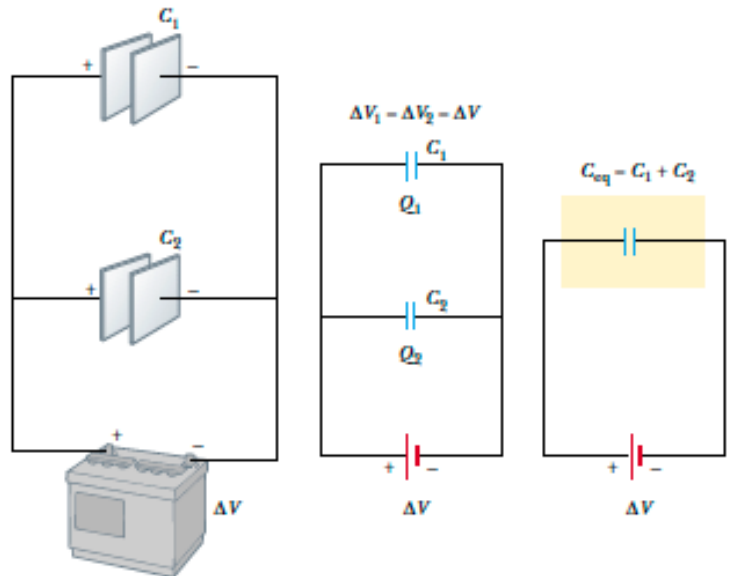
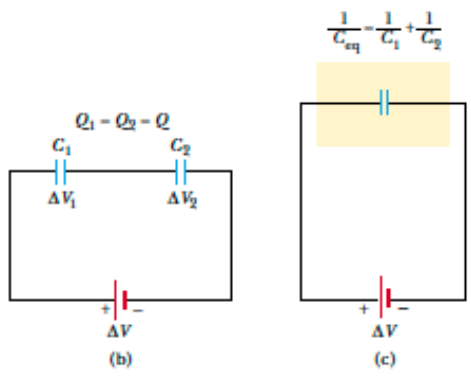
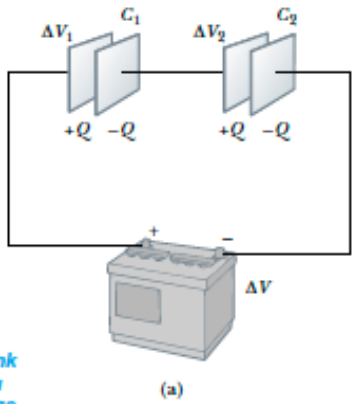
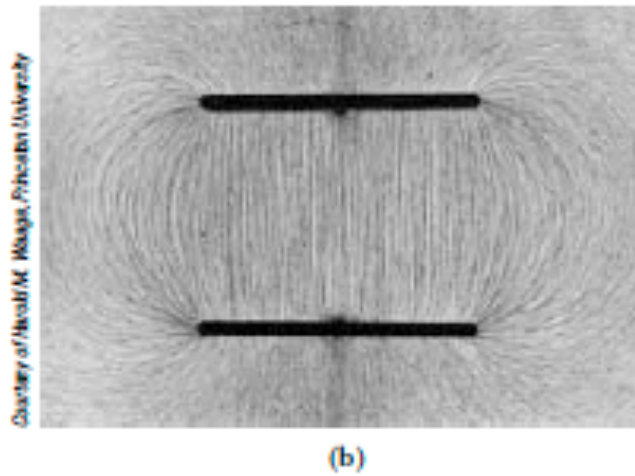
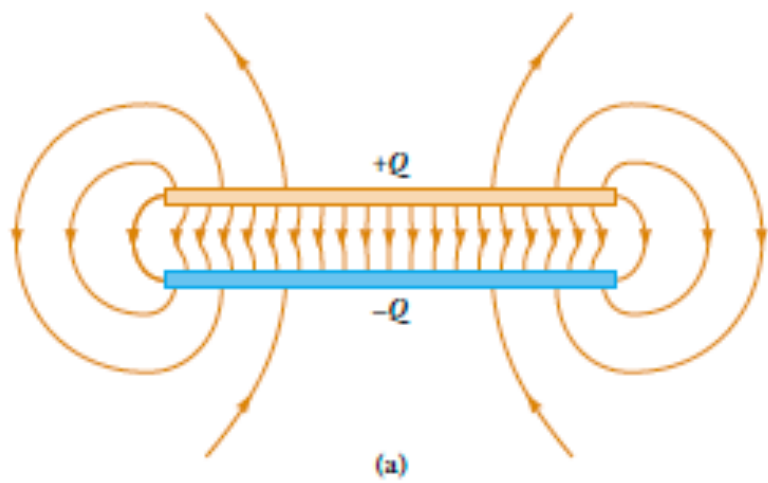
$$W = q \Delta V$$

Units of electric field

$$1 \frac{\text{N}}{\text{C}} = 1 \frac{\text{V}}{\text{m}}$$

$$E_x = - \frac{dV}{dx}$$

Capacitance and Dielectrics



Active Figure 26.10 (a) A series combination of two capacitors. The charges on the two capacitors are the same. (b) The circuit diagram for the series combination. (c) The equivalent capacitance can be calculated from the relationship

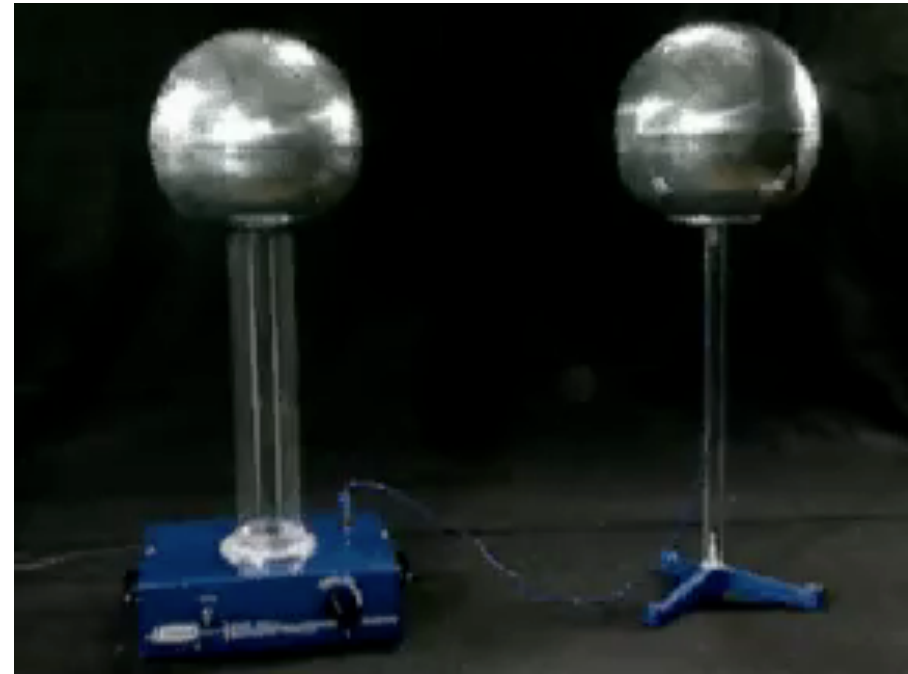
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

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four

Capacitance and Dielectrics



Figure 26.14 In a hospital or at an emergency scene, you might see a patient being revived with a defibrillator. The defibrillator's paddles are applied to the patient's chest, and an electric shock is sent through the chest cavity. The aim of this technique is to restore the heart's normal rhythm pattern.



Current and Resistance

